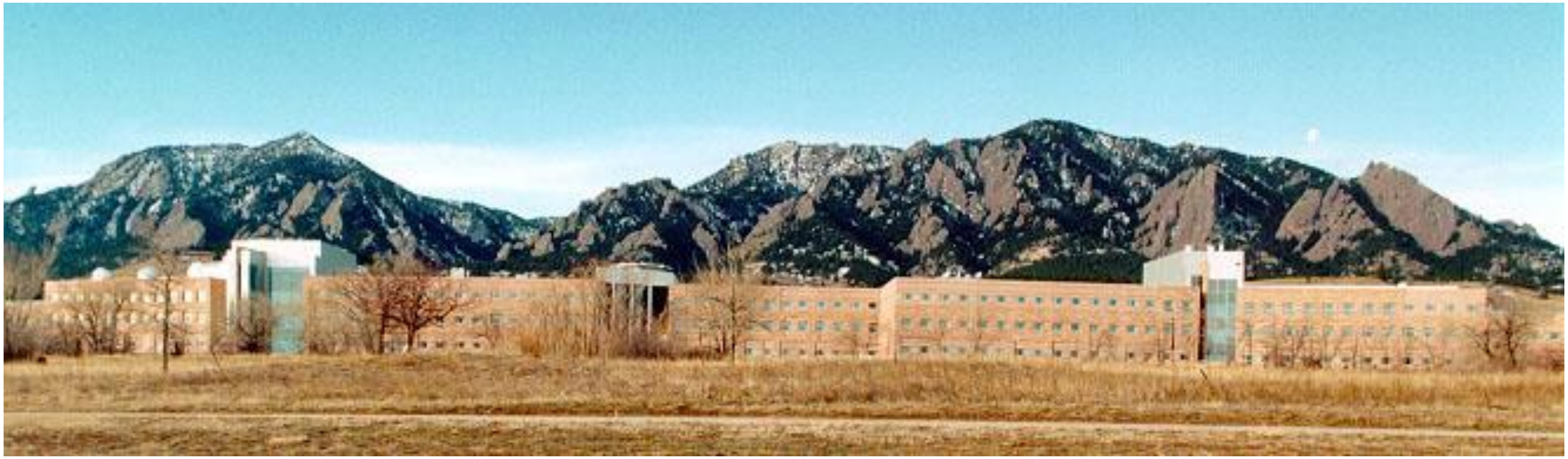


NOAA's National Geophysical Data Center

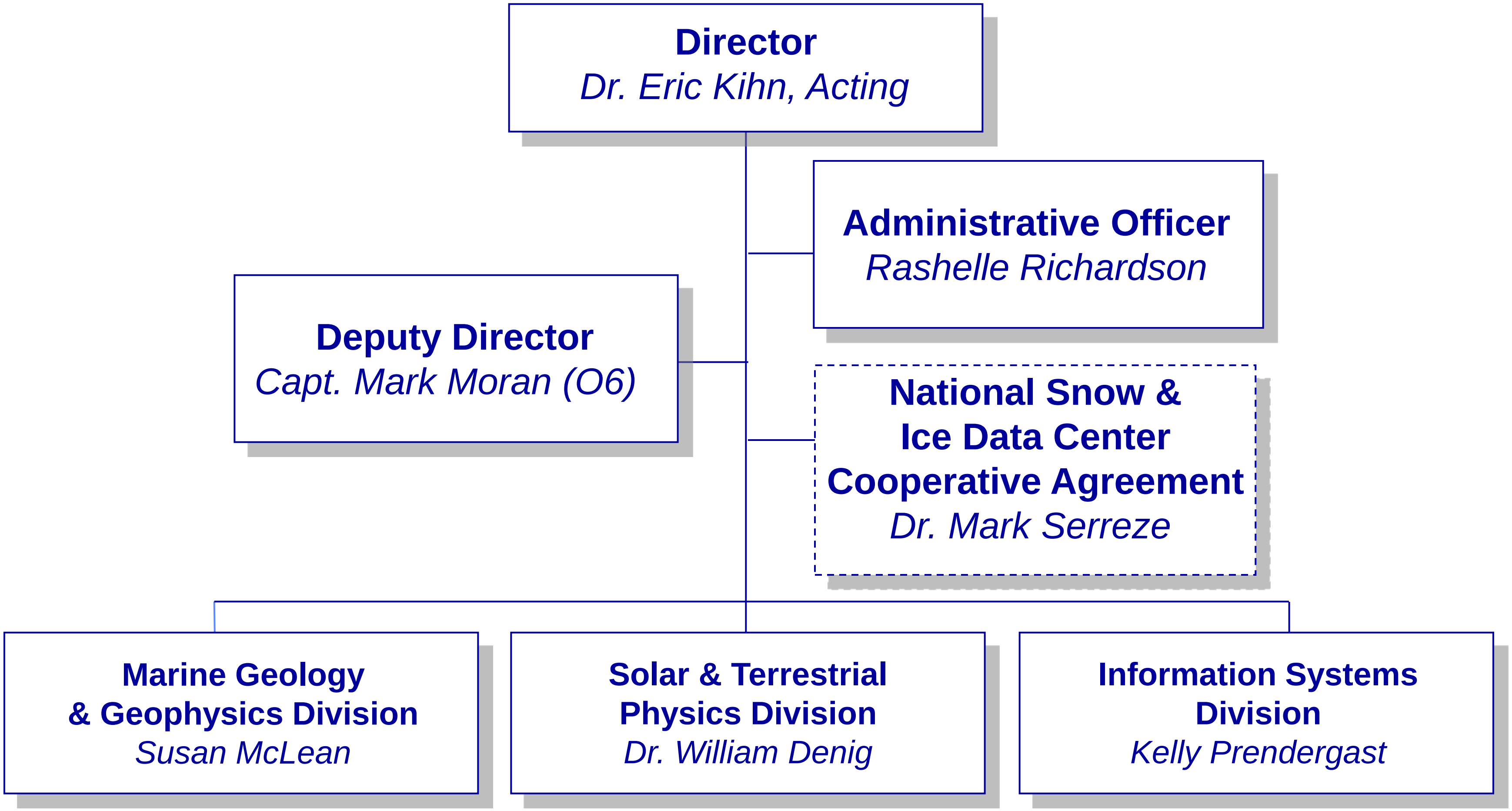
NOAA/NESDIS/NGDC's Space Based Observations and Capabilities

Eric A. Kihn, Acting Director
National Geophysical Data Center

4/11/2014

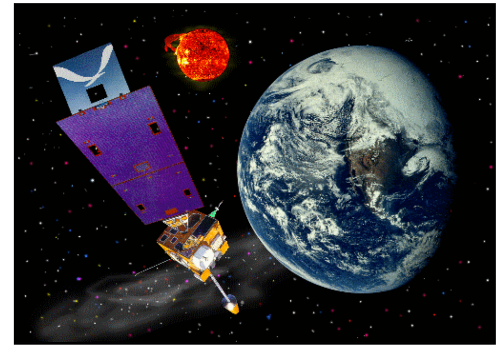
NGDC Organizational Chart

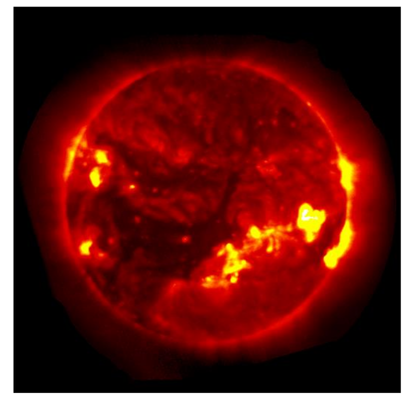
National Geophysical Data Center



Space Weather Team
Current Satellite Programs

Archiving Operational Space Weather Satellite Data





GOES Space Environment Monitor
- Geosynchronous Orbit, Since 1974
- Elements: In Situ Magnetic Fields
  Whole Sun X-ray Flux
  Energetic Particles

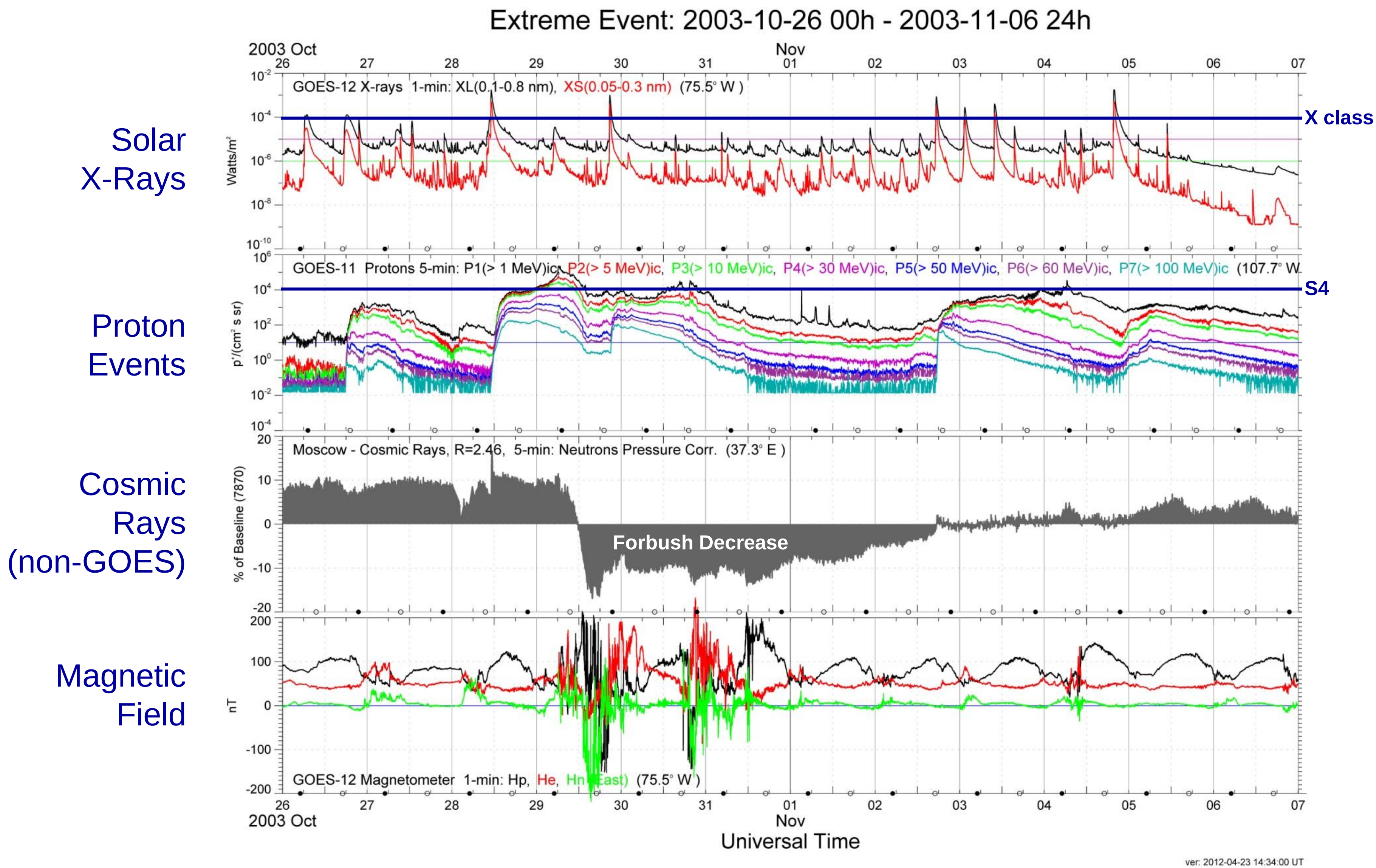
GOES Solar X-ray Imager – GOES 12-15
- X-ray Images taken every minute

POES/MetOp Energetic Particle Detector
- Polar Low Earth Orbit
- Energetic Particles Archived Since **1979**

Also DMSP Space Weather Sensors
- F16-18, SSIES/SSJ/SSM
- Processed data received from AFRL

GOES Environmental Data

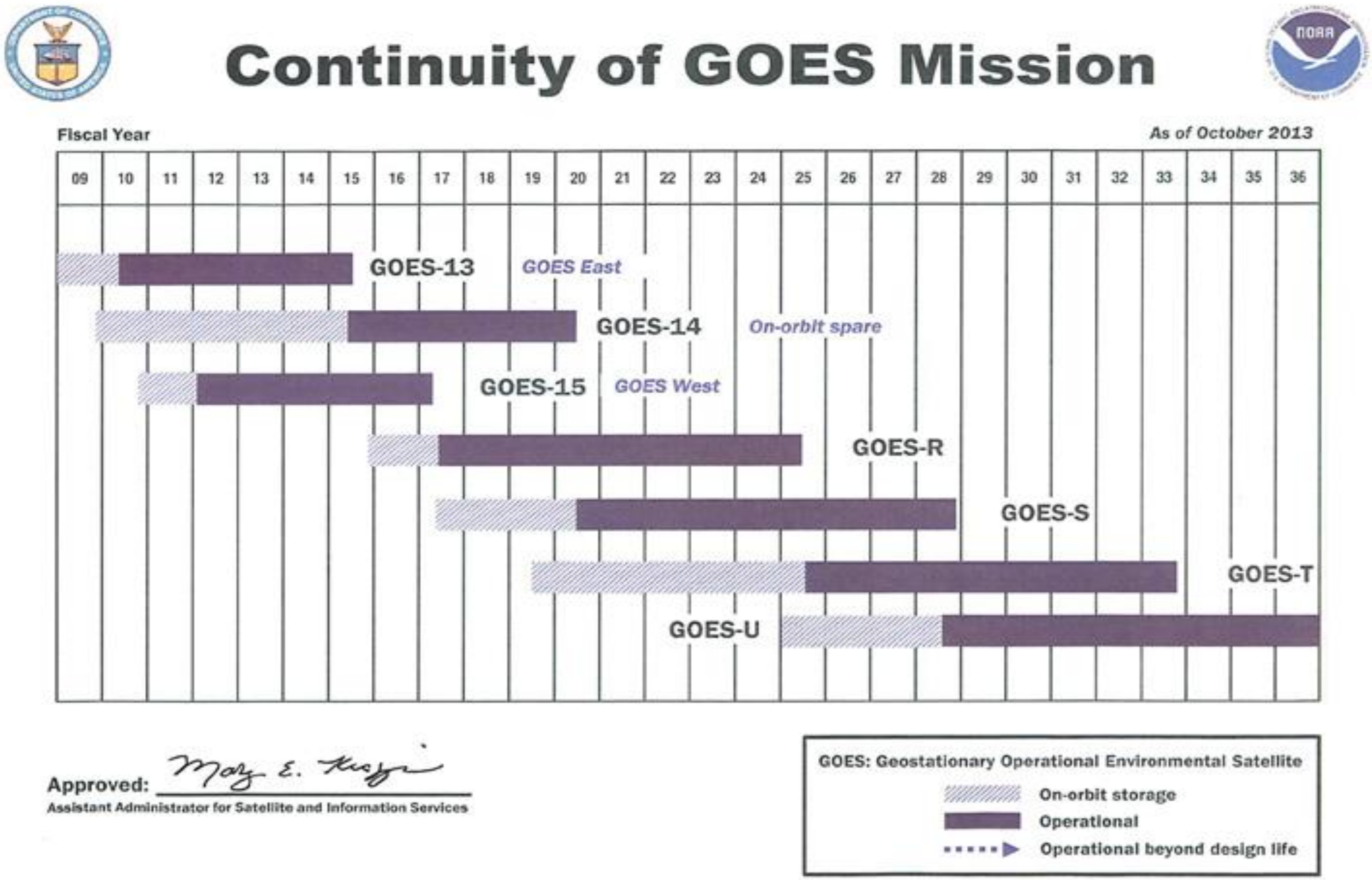
40 Years of Geostationary Measurements



http://www.ngdc.noaa.gov/stp/satellite/goes/index.html

Continuity of GEO Measurements

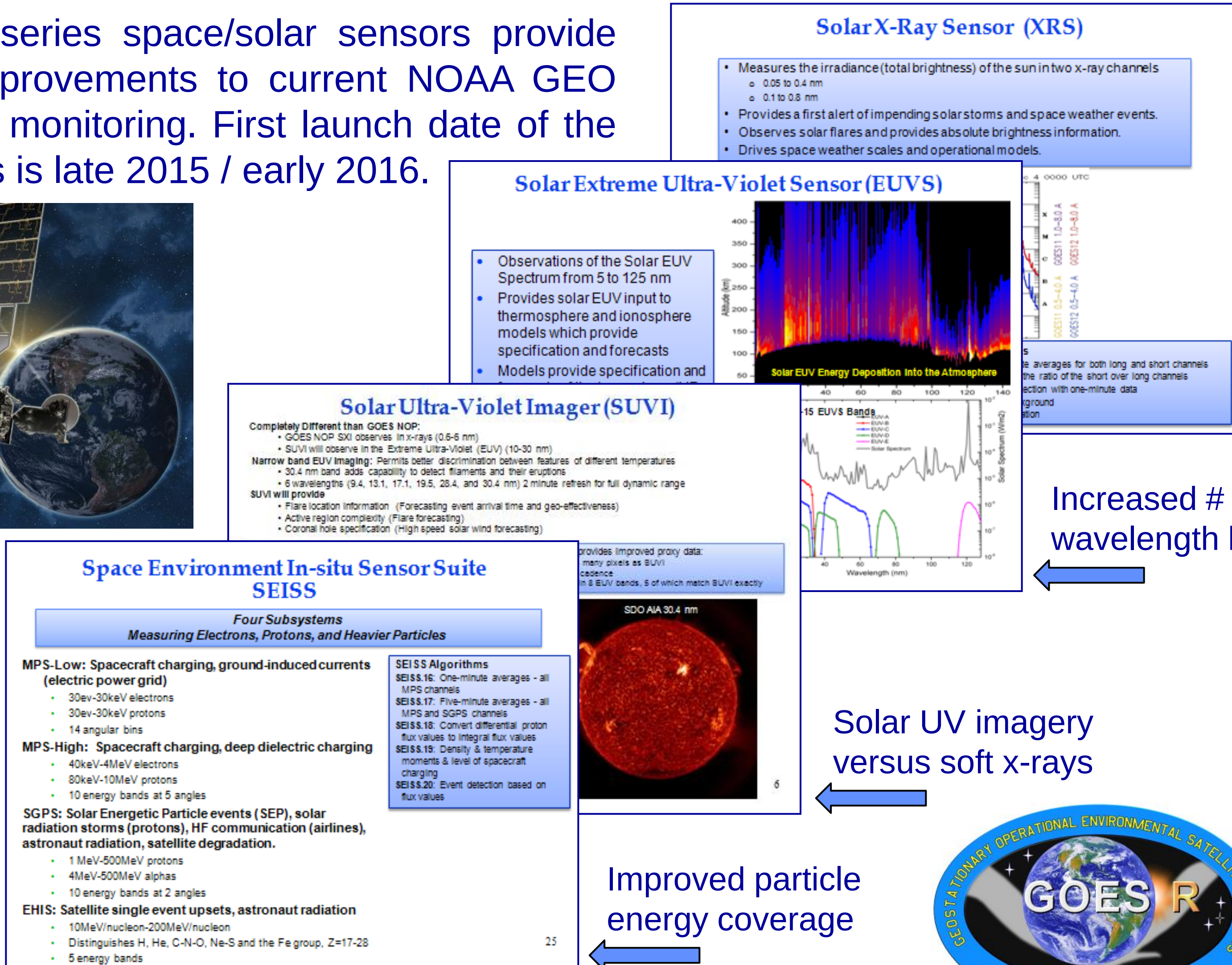
Transitioning to GOES-R/S/T/U



GOES-R (R/S/T/U) Series
Improved SWx Capabilities

The GOES-R series space/solar sensors provide incremental improvements to current NOAA GEO space weather monitoring. First launch date of the GOES-R series is late 2015 / early 2016.

Credit: Lockheed-Martin



Increased # of wavelength bands

Solar UV imagery versus soft x-rays

Improved particle energy coverage

GOES-R Space Weather

Space Weather L2+ Product Overview

Product Set 1 Complete

- XRS.04: One-minute averages for both long and short channels
- EUVS.03: One-minute averages of broad spectral bands
- SEISS.16: One-minute averages - all MPS channels
- SEISS.17: Five-minute averages - all MPS and SGPS channels
- SEISS.18: Convert differential proton flux values to integral flux values
- MAG.07: MAG data in alternate geophysical coordinate systems
- MAG.08: One-minute averages
- MAG.09: Comparison to quiet fields
- SUVI.07: Composite (wide dynamic range) images
- SUVI.09 and .10: Fixed and running difference images

Product Set 2 Complete

- XRS.05: Calculate the ratio of the short over long channels
- XRS.09: Daily Background
- XRS.07: Event Detection with one-minute data
- EUVS.03D: Daily averages of broad spectral bands
- EUVS.04: Event Detection
- SEISS.19: Density and temperature moments and level of spacecraft charging
- MAG.10: Magnetopause crossing detection
- SUVI.12: Coronal Hole Images
- SUVI.19: Thematic Map

Product Set 3 In Process

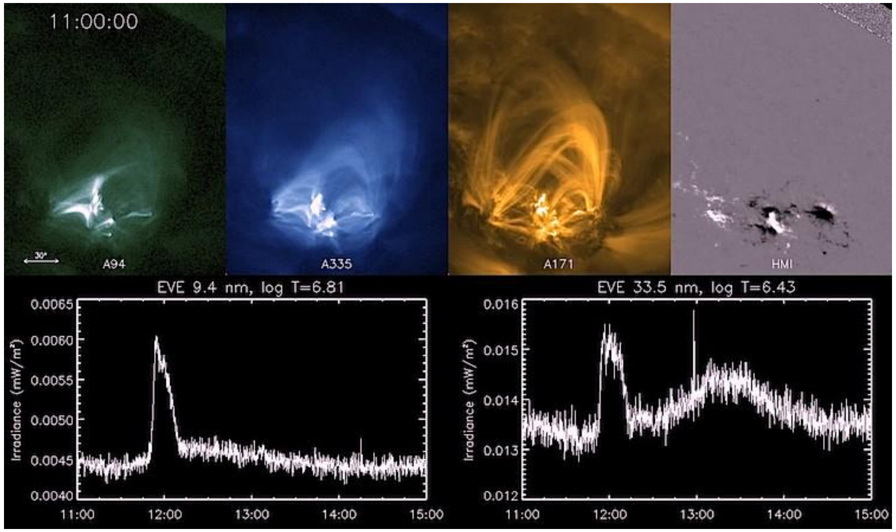
- XRS.10: Flare Location
- EUVS.05: Multi-wavelength Proxy
- SEISS.20: Event detection based on flux values
- MAG.12: Sudden Impulse (SI) detection
- SUVI.13: Bright Region Data
- SUVI.14: Flare Location (XFL) Reports
- SUVI.15: Coronal Hole Boundaries

Legacy Product
New Product

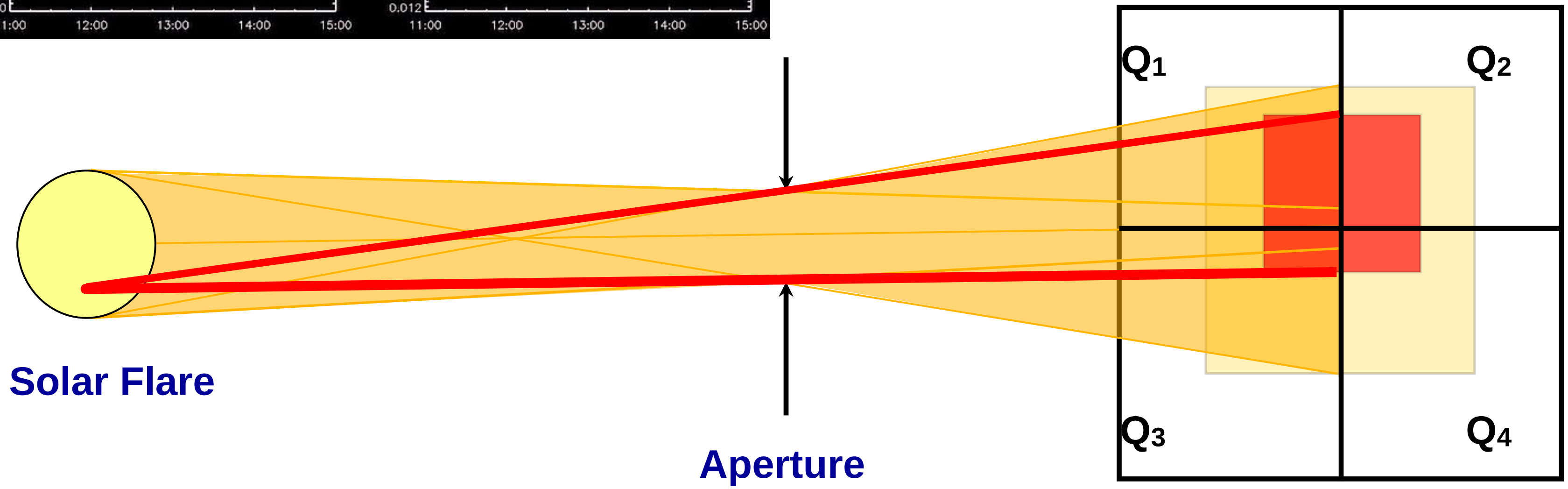
Algorithms leverage new sensor capabilities and extended environmental ranges.

- 26 Level 2+ Space Weather Products in three product sets
- 18 are operational legacy, 8 are new or have experimental heritage

GOES-R Space Weather
XRS.10 Flare Location

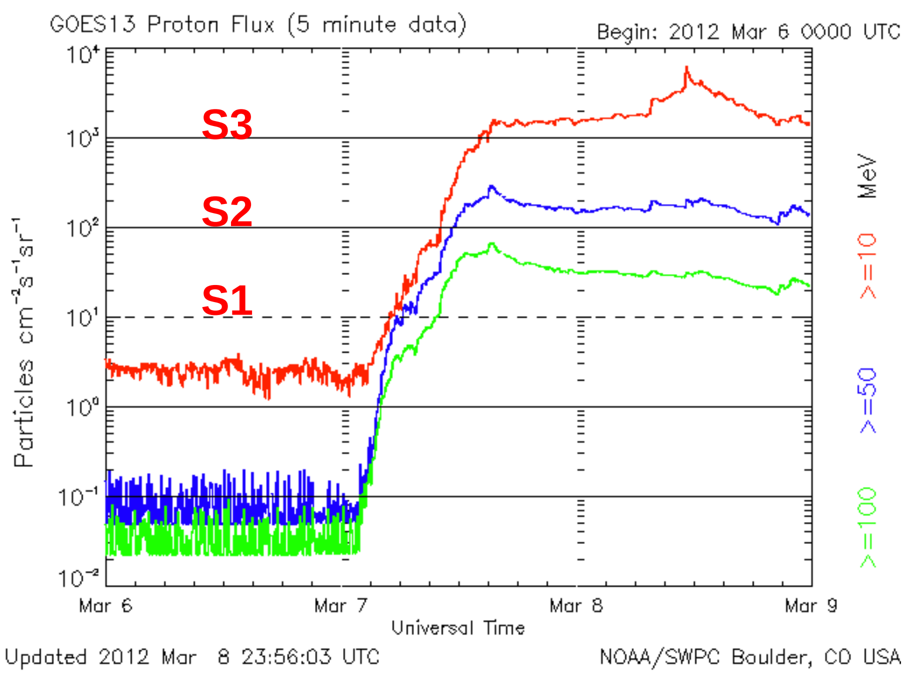


New quad-diode XRS design will provide an ability to locate solar flares on the disk. Algorithm will automate the locations of solar flares to aid in predicting impacts to earth-based and satellite systems.



GOES-R Space Weather
XRS.10 Flare Location

Algorithm will report all event detection parameters, peak fluxes and event fluences based on SEISS SGPS measurements. Adding a rate of rise quantity to the event onset detection will enhance the algorithm's prediction capabilities.



NOAA Space Weather Scales

Category: Scale	Descriptor	Effect (Duration of event will influence severity of effects)	Physical measure	Average Frequency (1 cycle = 11 years)
Geomagnetic Storms			Kp values* determined every 3 hours	Number of storm events when Kp level was met; (number of storm days)
G 5	Extreme	Power systems: widespread voltage control problems and protective system problems can occur, some grid systems may experience complete collapse or blackouts. Transformers may experience damage. Spacecraft operations: may experience extensive surface charging, problems with orientation, uplink/downlink and tracking satellites. Other systems: pipeline currents can reach hundreds of amps, HF (high frequency) radio propagation may be impossible in many areas for one to two days, satellite navigation may be degraded for days, low-frequency radio navigation can be out for hours, and aurora has been seen as low as Florida and southern Texas (typically 40° geomagnetic lat.).**	Kp=9	4 per cycle (4 days per cycle)
G 4	Severe	Power systems: possible widespread voltage control problems and some protective systems will mistakenly trip out key assets from the grid. Spacecraft operations: may experience surface charging and tracking problems, corrections may be needed for orientation problems. Other systems: induced pipeline currents affect preventive measures, HF radio propagation sporadic, satellite navigation degraded for hours, low-frequency radio navigation disrupted, and aurora has been seen as low as Alabama and northern California (typically 45° geomagnetic lat.).**	Kp=8	100 per cycle (60 days per cycle)
G 3	Strong	Power systems: voltage corrections may be required, false alarms triggered on some protection devices. Spacecraft operations: surface charging may occur on satellite components, drag may increase on low-Earth-orbit satellites, and corrections may be needed for orientation problems. Other systems: intermittent satellite navigation and low-frequency radio navigation problems may occur, HF radio may be intermittent, and aurora has been seen as low as Illinois and Oregon (typically 50° geomagnetic lat.).**	Kp=7	200 per cycle (130 days per cycle)
G 2	Moderate	Power systems: high-latitude power systems may experience voltage alarms, long-duration storms may cause transformer damage. Spacecraft operations: corrective actions to orientation may be required by ground control; possible changes in drag affect orbit predictions. Other systems: HF radio propagation can fade at higher latitudes, and aurora has been seen as low as New York and Idaho (typically 55° geomagnetic lat.).**	Kp=6	600 per cycle (360 days per cycle)
G 1	Minor	Power systems: weak power grid fluctuations can occur. Spacecraft operations: minor impact on satellite operations possible. Other systems: migratory animals are affected at this and higher levels; aurora is commonly visible at high latitudes (northern Michigan and Maine).**	Kp=5	1700 per cycle (900 days per cycle)

* Based on this measure, but other physical measures are also considered.
** For specific locations around the globe, use geomagnetic latitude to determine likely sightings (see www.swpc.noaa.gov/Aurora)

Scale	Descriptor	Effect	Physical measure	Average Frequency
Solar Radiation Storms			Flux level of ≥ 10 MeV particles (ions)*	Number of events when flux level was met**
S 5	Extreme	Biological: unavoidable high radiation hazard to astronauts on EVA (extra-vehicular activity); passengers and crew in high-flying aircraft at high latitudes may be exposed to radiation risk. *** Satellite operations: satellites may be rendered useless, memory impacts can cause loss of control, may cause serious noise in image data, star-trackers may be unable to locate sources; permanent damage to solar panels possible. Other systems: complete blackout of HF (high frequency) communications possible through the polar regions, and position errors make navigation operations extremely difficult.	10^5	Fewer than 1 per cycle
S 4	Severe	Biological: unavoidable radiation hazard to astronauts on EVA; passengers and crew in high-flying aircraft at high latitudes may be exposed to radiation risk.*** Satellite operations: may experience memory device problems and noise on imaging systems; star-tracker problems may cause orientation problems, and solar panel efficiency can be degraded. Other systems: blackout of HF radio communications through the polar regions and increased navigation errors over several days are likely.	10^4	3 per cycle
S 3	Strong	Biological: radiation hazard avoidance recommended for astronauts on EVA; passengers and crew in high-flying aircraft at high latitudes may be exposed to radiation risk.*** Satellite operations: single-event upsets, noise in imaging systems, and slight reduction of efficiency in solar panel are likely. Other systems: degraded HF radio propagation through the polar regions and navigation position errors likely.	10^3	10 per cycle
S 2	Moderate	Biological: passengers and crew in high-flying aircraft at high latitudes may be exposed to elevated radiation risk.*** Satellite operations: infrequent single-event upsets possible. Other systems: effects on HF propagation through the polar regions, and navigation at polar cap locations possibly affected.	10^2	25 per cycle
S1	Minor	Biological: none. Satellite operations: none. Other systems: minor impacts on HF radio in the polar regions.	10	50 per cycle

* Flux levels are 5 minute averages. Flux in particles·s^{-1}·$ster^{-1}$·cm^{-2} Based on this measure, but other physical measures are also considered.
** These events can last more than one day.
*** High energy particle (>100 MeV) are a better indicator of radiation risk to passenger and crews. Pregnant women are particularly susceptible.

Scale	Descriptor	Effect	Physical measure	Average Frequency
Radio Blackouts			GOES X-ray peak brightness by class and by flux*	Number of events when flux level was met; (number of storm days)
R 5	Extreme	HF Radio: Complete HF (high frequency**) radio blackout on the entire sunlit side of the Earth lasting for a number of hours. This results in no HF radio contact with mariners and en route aviators in this sector. Navigation: Low-frequency navigation signals used by maritime and general aviation systems experience outages on the sunlit side of the Earth for many hours, causing loss in positioning. Increased satellite navigation errors in positioning for several hours on the sunlit side of Earth, which may spread into the night side.	X20 ($2x10^{-3}$)	Fewer than 1 per cycle
R 4	Severe	HF Radio: HF radio communication blackout on most of the sunlit side of Earth for one to two hours. HF radio contact lost during this time. Navigation: Outages of low-frequency navigation signals cause increased error in positioning for one to two hours. Minor disruptions of satellite navigation possible on the sunlit side of Earth.	X10 (10^{-3})	8 per cycle (8 days per cycle)
R 3	Strong	HF Radio: Wide area blackout of HF radio communication, loss of radio contact for about an hour on sunlit side of Earth. Navigation: Low-frequency navigation signals degraded for about an hour.	X1 (10^{-4})	175 per cycle (140 days per cycle)
R 2	Moderate	HF Radio: Limited blackout of HF radio communication on sunlit side of the Earth, loss of radio contact for tens of minutes. Navigation: Degradation of low-frequency navigation signals for tens of minutes.	M5 ($5x10^{-5}$)	350 per cycle (300 days per cycle)
R 1	Minor	HF Radio: Weak or minor degradation of HF radio communication on sunlit side of the Earth, occasional loss of radio contact. Navigation: Low-frequency navigation signals degraded for brief intervals.	M1 (10^{-5})	2000 per cycle (950 days per cycle)

* Flux, measured in the 0.1-0.8 nm range, in W·m^{-2}. Based on this measure, but other physical measures are also considered.
** Other frequencies may also be affected by these conditions.

URL: *www.swpc.noaa.gov/NOAAscales*

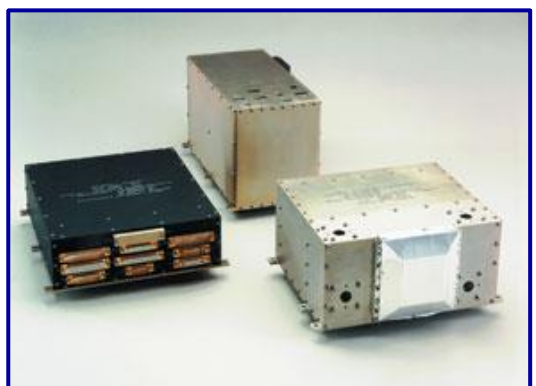
April 7, 2011

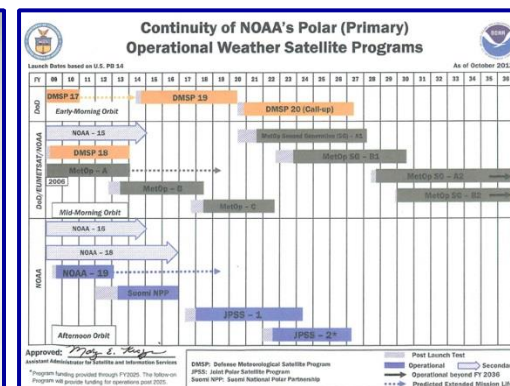
An End of an Era (since 1978)

LEO Space Environmental Monitor (SEM)

http://www.ngdc.noaa.gov/stp/satellite/poes/index.html

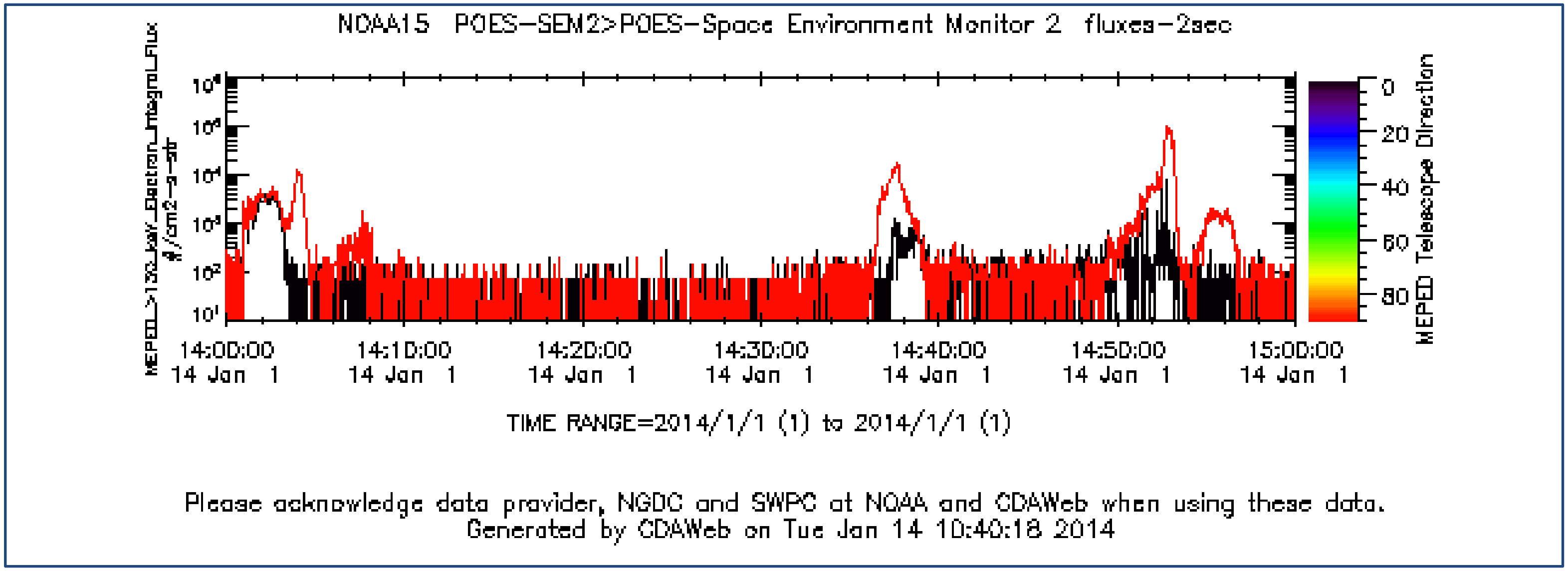
- NOAA-19 is the last NOAA satellite in polar LEO to provide operational SWx data
  - ➢ NOAA-19 Extended EOL – CY19
  - ➢ NOAA-15/16/18 still provide SEM data
- European MetOp satellites carry NOAA SEM-2 packages
  - ➢ MetOp A – CY2006 – 2014 (SEM-2)
  - ➢ MetOp B – CY2013 – 2018 (SEM-2)
  - ➢ MetOp C – CY2018 – 2022 (SEM-2)





Secondary Provider

Coordinated Data Analysis Web



New NOAA datasets will soon be available via CDAWeb

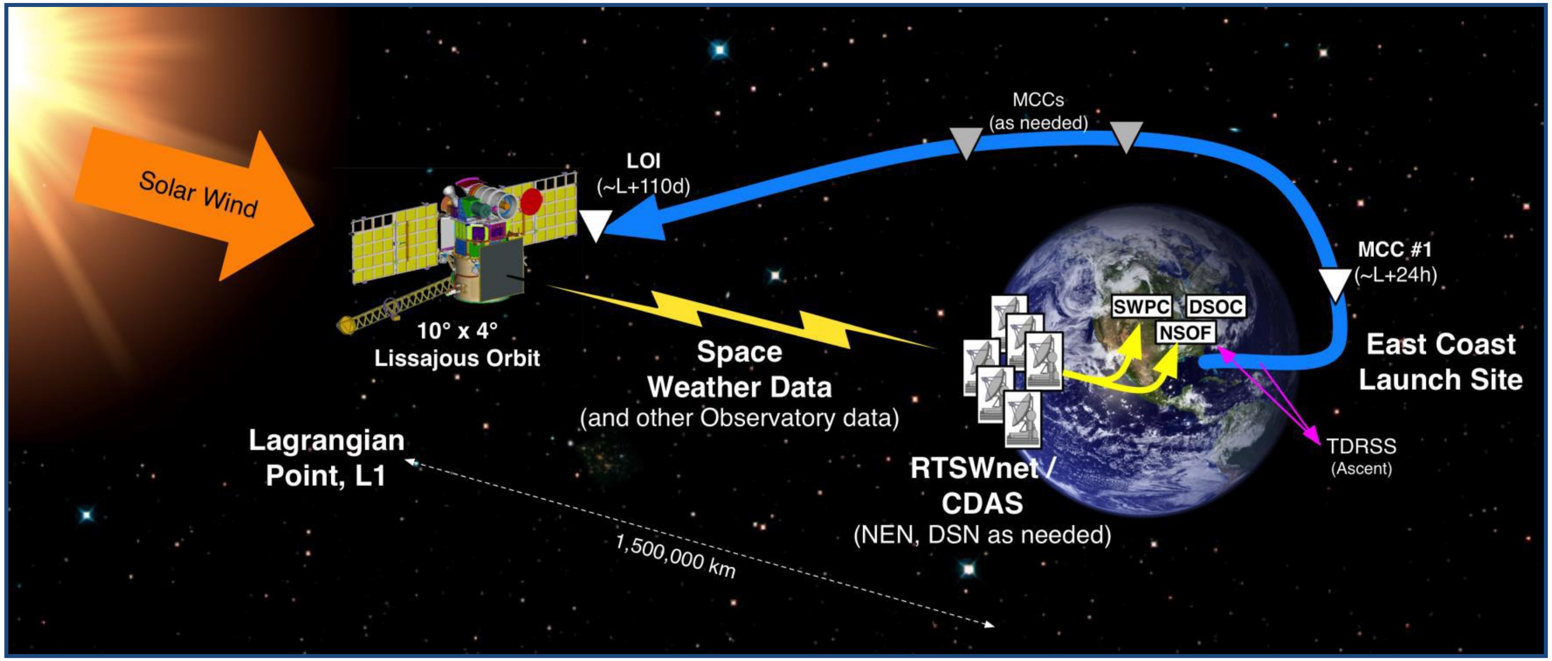
NOAA15/16/18/19; MetOp-A/MetOp-B

MEPED:	**e: >40; >130; >287; >612 keV**	**integral energy flux**
	p: 39; 115; 332; 1105; 2723 keV	**differential energy flux**
TED:	**e: 50 eV – 1 keV; 1 keV – 20 keV**	**channel energy flux**
	p: 50 eV – 1 keV; 1 keV – 20 keV	**channel energy flux**

Contact Rob Redmon or Bob McGuire for details

New Capability

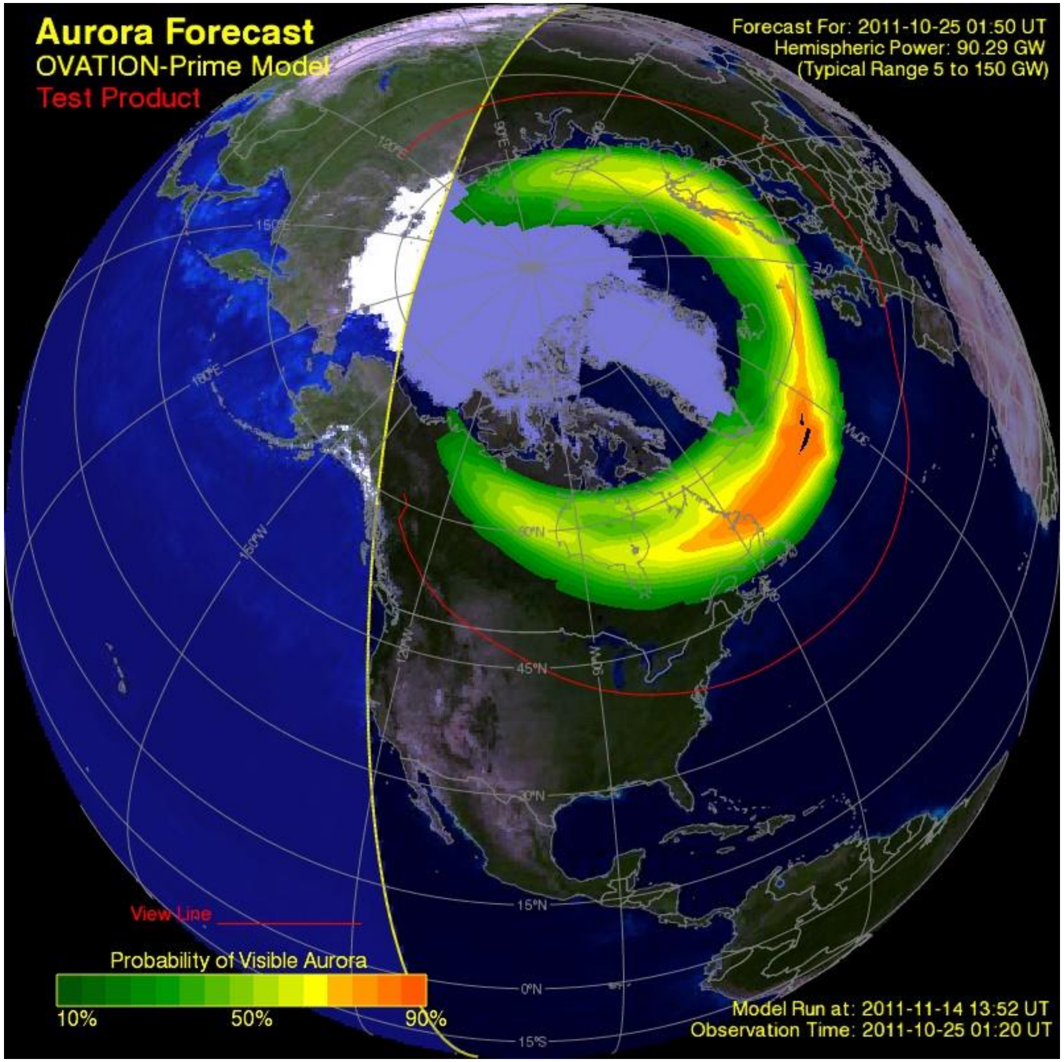
Operational SWx Data from L1

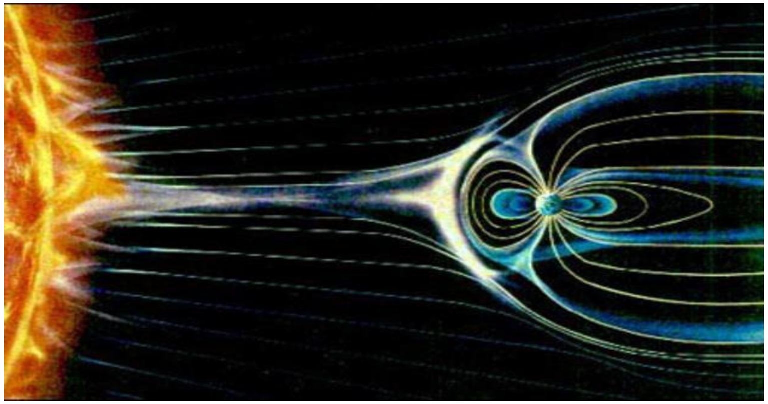


- The DSCOVR spacecraft will measure the solar wind (n_p, v_p, t_p) and the interplanetary magnetic field at 240 R_e forward of the earth
- Space-X Falcon 9 launch scheduled for 13 Jan 2015; DSCOVR on-station in 110 days
- DSCOVR solar wind/IMF data downlinked via the Real-Time Solar Wind Network (RTSWnet) as is currently done for ACE
- SWPC provides real-time data / NGDC provides retrospective data (>1 day)

Expanded Products and Services
Ovation Auroral Forecast Model

- Methodology developed at JHU/APL
  - 30-40 min forecast driven by ACE solar wind and interplanetary magnetic field data – **ops will transition to DSCOVR**
  - Model currently running in real-time at NGDC – link
  - Customer products available from SWPC – link
- Plans:
  - Transition Ovation to full operations in March 2014
  - Test and implement model upgrades for reduced noise and capability to handle larger storms





DSCOVR Follow-on

Operational Solar Wind / CME Imagery Missions

NOAA is committed to continued solar wind/CME monitoring

Solar Wind – Commercial and other options:

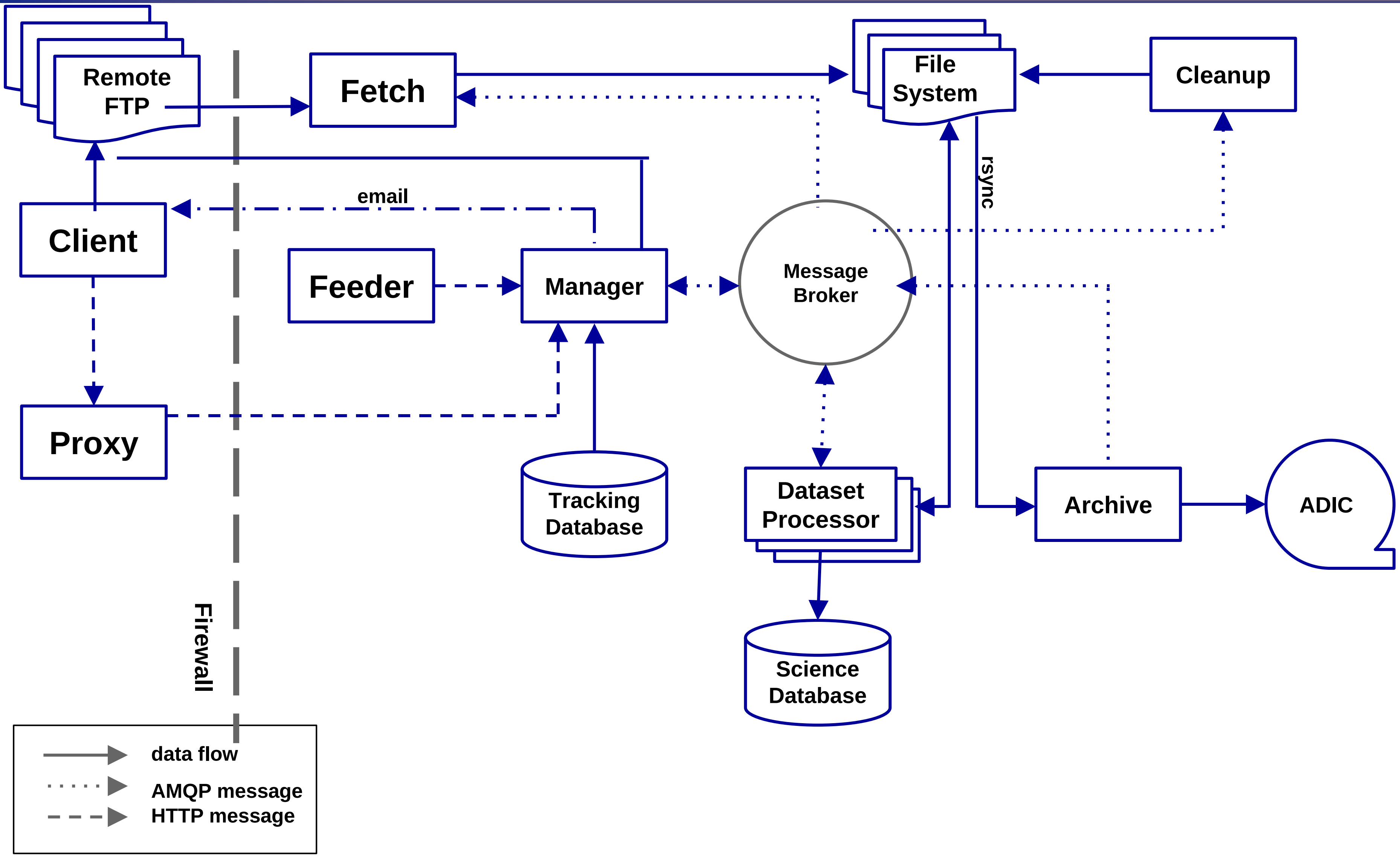
- Evaluate Sunjammer mission performance data for improved space weather forecasts
- Evaluate business case for Sunjammer commercial data buy option
- Examine sensor concepts for improved sensor performance
- Refresh cost estimates for other options such as government satellites

CME Imagery

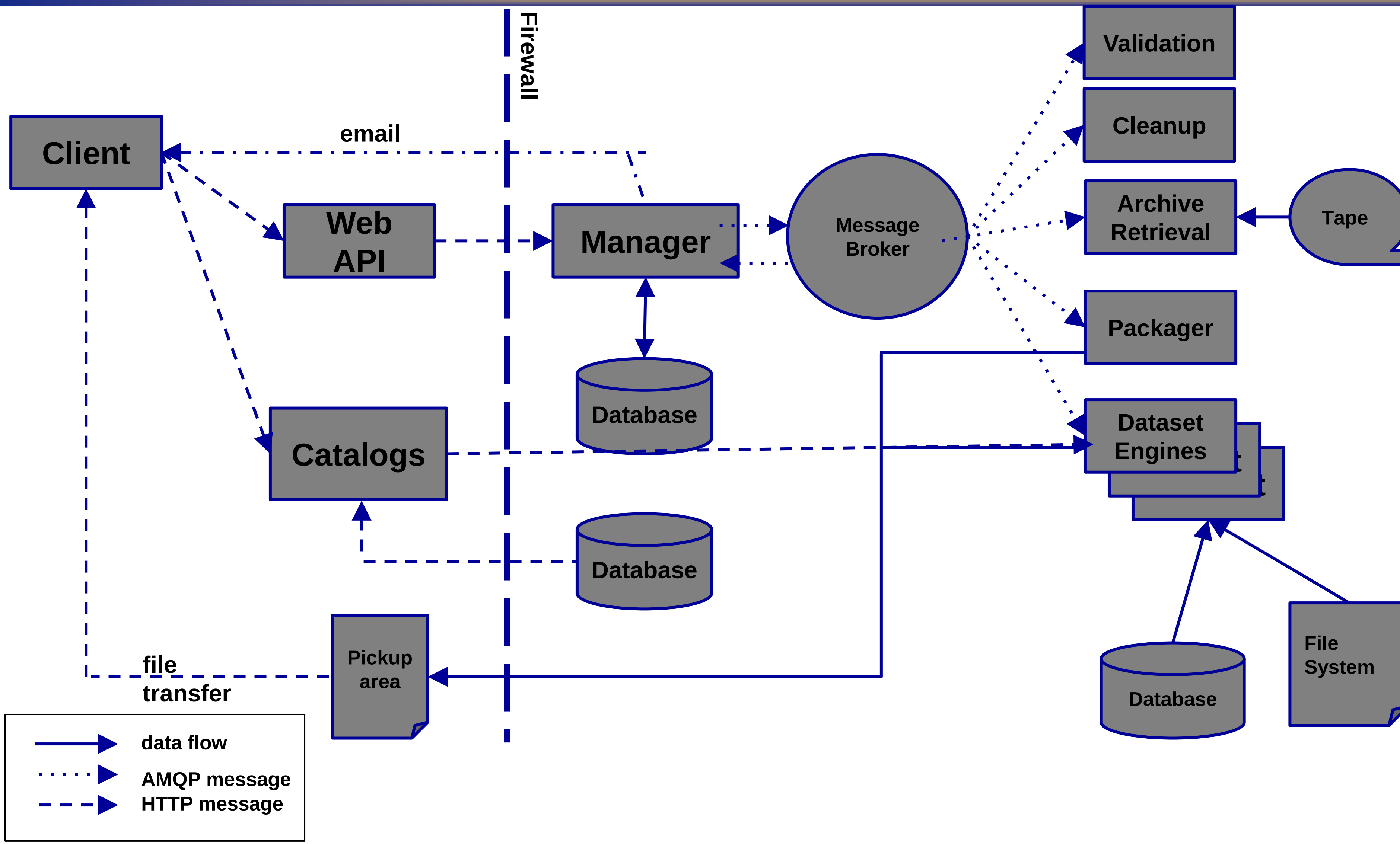
- Continue CCOR risk reduction studies at NRL
- Pursuing STP launch option
- Include CME imagery option in DSCOVR follow-on studies

Infrastructure Development

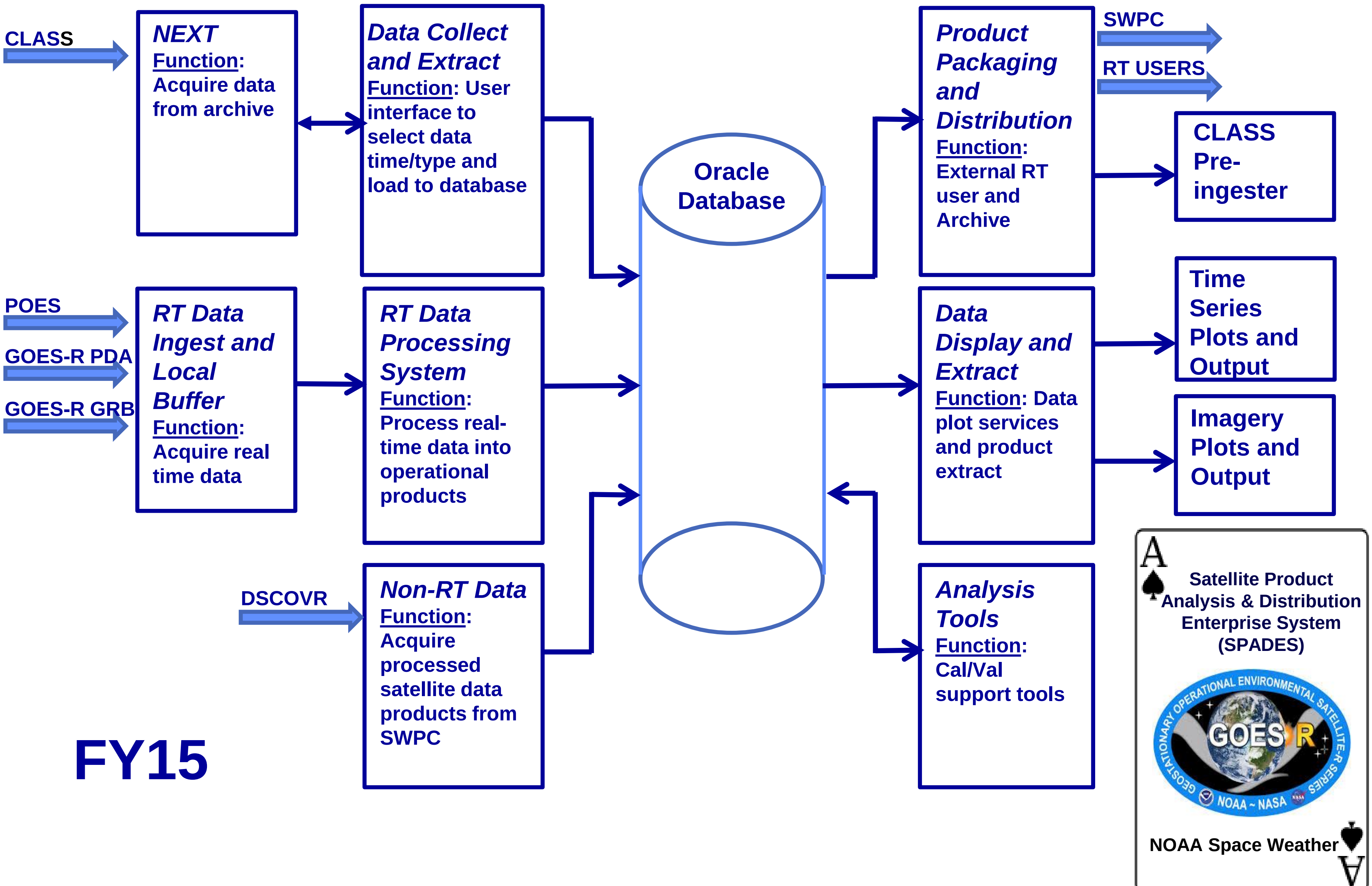
NGDC Common Ingest Overview



NEXT System Overview



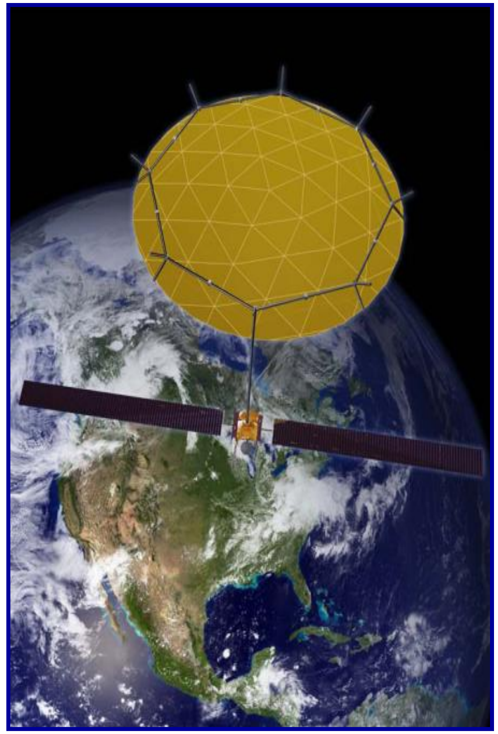
NGDC Satellite Product Analysis and Distribution Enterprise System (Phase 4 – GOES-R Ops)

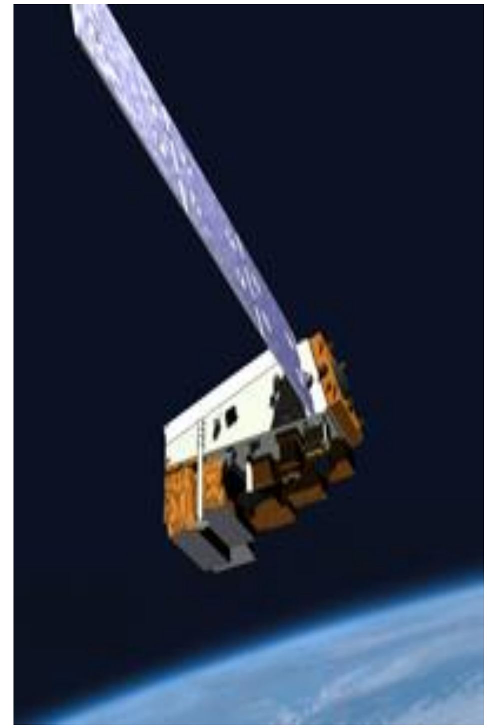


FY15

Future Plans

Space Weather Team
Satellite Anomaly Assessments





<u>Case 1 – Galaxy-15</u>

Orbit: Geosynchronous

Anomaly Date:
05 April 2010 @09:48

Probable Cause:
Internal Charging/ESD

<u>Case 2 – SkyTerra-1</u>

Orbit: Geosynchronous

Anomaly Date:
07 March 2012 @14:43

Probable Cause:
Single-Event Upset

<u>Case 3 – NPP/VIIRS</u>

Orbit: Polar LEO

Anomaly Date:
Various

Probable Cause:
Single-Event Upsets

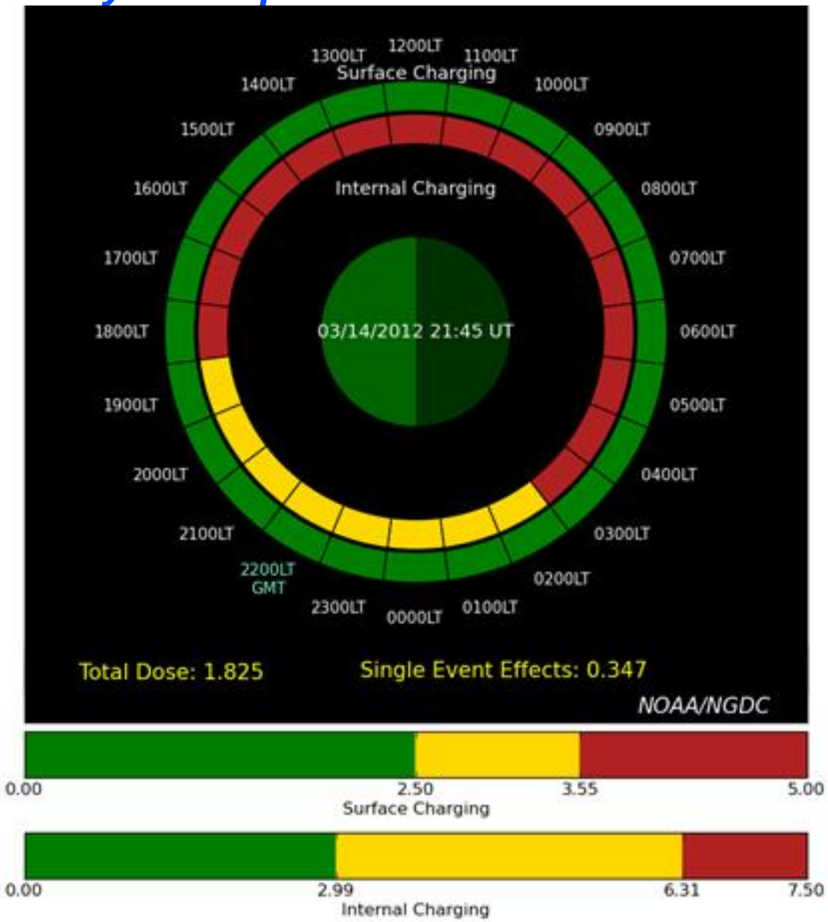
Satellite Anomaly
Environmental Assessment

***Mission:** Identify, Assess and Mitigate the Deleterious Effects of Space on Satellite Survivability and Operations*

Satellite anomalies are often caused by environmental effects. NGDC will support the development of environmental "packages" to aid assessment teams.

Actions:

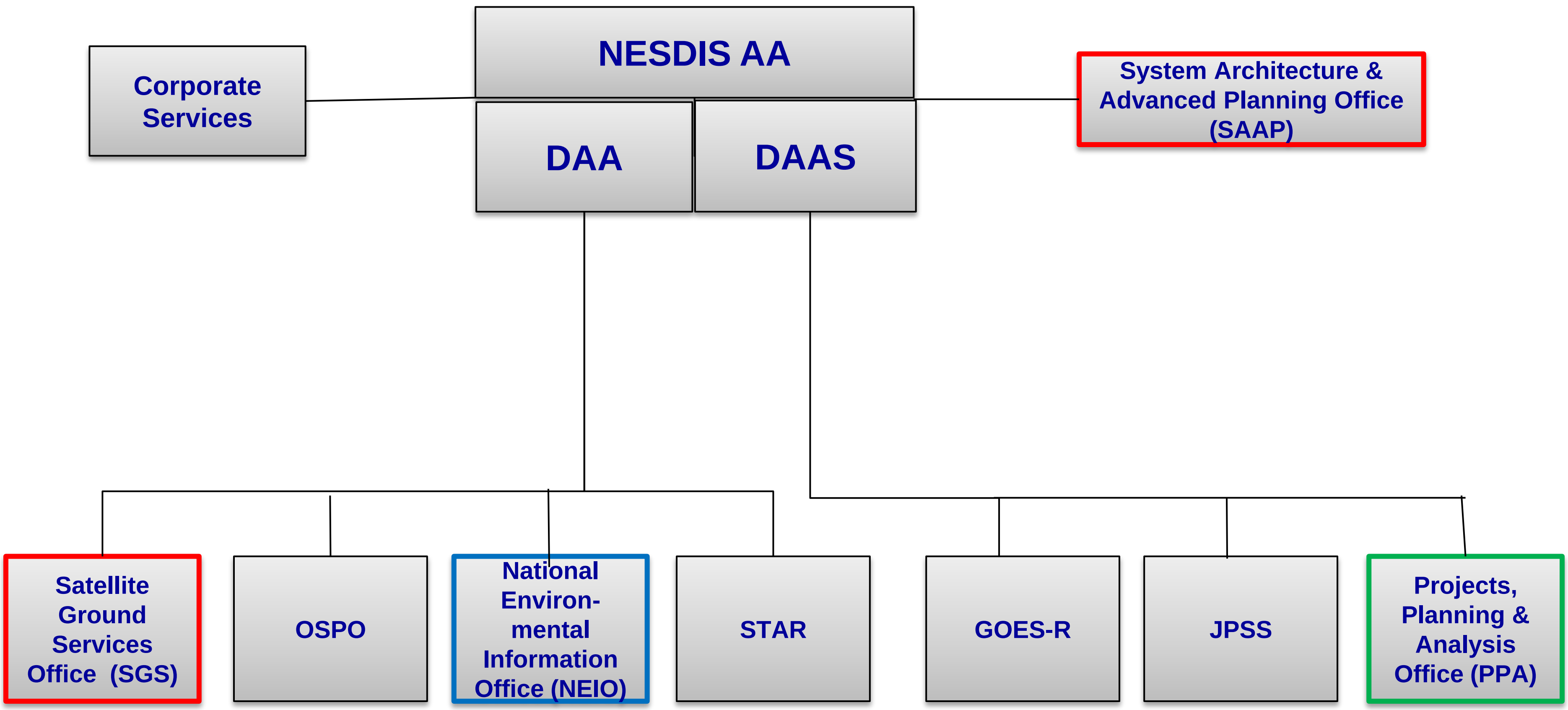
- **Develop software capability and supporting infrastructure FY-14/15**
- **Establish ISO standards for "worst-case" environments as requested by U.S. satellite manufacturers.**
- **Provide post-mortem environmental assessments for satellite failure review boards. Recent assessments[1] have been conducted for Galaxy-15, SkyTerra-1 and VIIRS.**



Space Environment Anomalies Expert System Real-Time (SEAESRT)[2]

NESDIS Organization

Strengthening NESDIS



New organizational elements

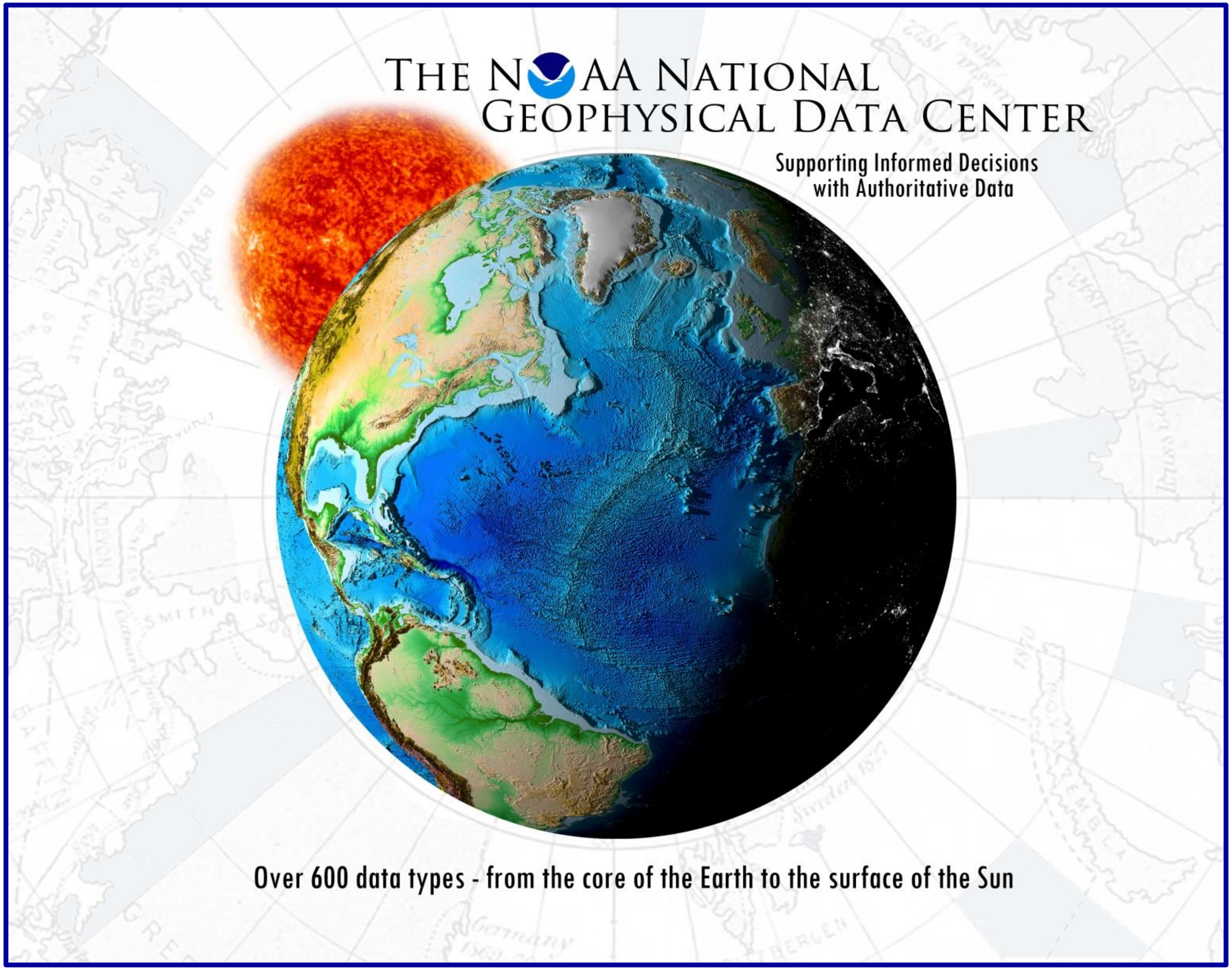
Data Center Consolidation

Restructured (Formally Office of Systems Development)

Summary – Take-Aways

- NGDC provides stewardship, archive, and access for a variety of operational space weather data and products from NOAA's existing fleet of environmental satellites (GOES and POES/MetOp)
- A new generation of GOES (R/S/T/U) is coming and will continue to acquire GEO measurements through 2036
- An operational L1 satellite will join the archive in 2015
- After POES/MetOp there are no planned operational (or otherwise) satellites acquiring particle/radiation data in LEO – possible AF initiative (HEALER – Joe Mazer/Aerospace)
- New near-term NOAA operational sources of space weather data include DSCOVR at the L1 Lagrange location and COSMIC-II in LEO – Sunjammer and DSCOVR follow-on are also in the mix
- NGDC has made a significant investment in infrastructure to better serve the space weather community.

Thank You!


THE NOAA NATIONAL
GEOPHYSICAL DATA CENTER
Supporting Informed Decisions
with Authoritative Data
Over 600 data types - from the core of the Earth to the surface of the Sun